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Physics 132

Exam 3

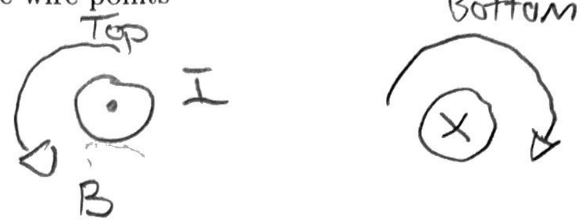
Instructions: This exam contains 5 multiple choice questions worth 4 points each and 4 problems worth 20 points each. Do not refer to any book or notes during the exam. The time limit for this test is 50 minutes.

(I)

Section I - Circle the letter that corresponds to the correct answer.

+66/100

1. A horizontal wire carries a current straight toward you. From your point of view, the magnetic field at a point directly below the wire points



a) directly away from you.

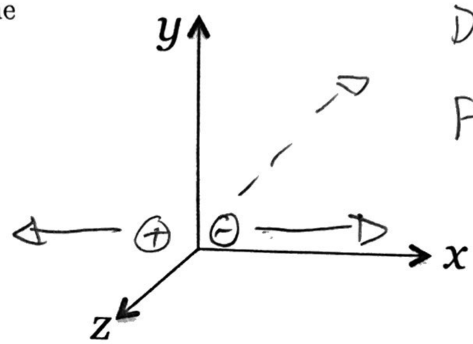
b) to the left.

c) to the right.

d) directly toward you.

e) vertically upward.

2. An electron moving in the direction of the $+x$-axis enters a magnetic field. If the electron experiences a magnetic deflection in the $-y$ direction, the direction of the magnetic field in this region points in the direction of the



Deflection = F

F = qvB

a) $+z$-axis.

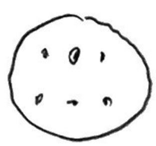
b) $-z$-axis.

c) $-x$-axis.

d) $+y$-axis.

e) $-y$-axis.

3. A circular loop of wire lies in the plane of the paper. An increasing magnetic field points out of the paper. What is the direction of the induced current in the loop?



Increasing

compensate field downward

a) counter-clockwise then clockwise.

b) clockwise then counter-clockwise.

c) clockwise.

d) counter-clockwise.

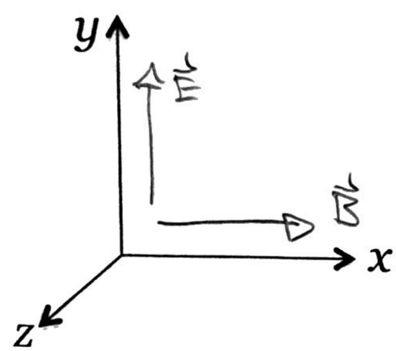
e) there is no current induced in the loop.

4. In an electromagnetic wave, the electric and magnetic fields are orientated such that they are

a) parallel to one another and perpendicular to the direction of wave propagation.
b) parallel to one another and parallel to the direction of wave propagation.
c) perpendicular to one another and perpendicular to the direction of wave propagation.
d) perpendicular to one another and parallel to the direction of wave propagation.

5. If the magnetic field of an electromagnetic wave is in the $+x$-direction and the electric field of the wave is in the $+y$-direction, the wave is traveling in the

a) xy-plane.
b) $+z$-direction.
c) $-z$-direction.
d) $-x$-direction.
e) $-y$-direction.



V= E x B

+20/20

Section II - For credit, show all work!

12/20

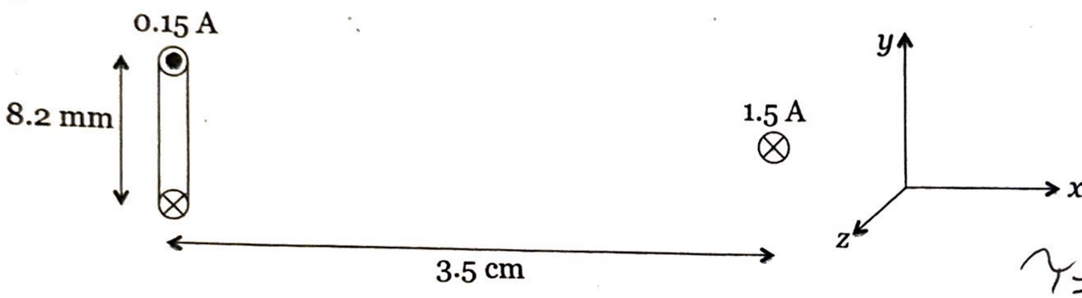
1. Consider a current loop and a very long wire as illustrated in the figure below. Notice that the current in the wire is perpendicular to the page and the figure shows the cross-section of the current loop.

   a) What is the magnetic field (direction and magnitude) of the current carrying wire at the location of the center of the current loop.

   b) What is the magnetic dipole moment (direction and magnitude) of the current loop.

   c) What is the magnetic field (direction and magnitude) of the current loop at the location of the very long wire. Notice that the current loop-wire distance is much greater than the radius of the loop.

   d) What is the magnitude of the torque on the current loop?



$\tau = \mu B \sin\theta$

a.) $B_{loop} = \frac{\mu_0}{2} \frac{I R^2}{(z^2 + R^2)^{3/2}} = \frac{\mu_0}{2} \frac{NI}{R}$ × -4

$I = 1.5A$ $\quad z = 0$

$\mu_0 = 4\pi \times 10^{-7} Tm/A$

$R = 8.2 \times 10^{-3} m$

$\boxed{B_{loop} = 1.149 \times 10^{-4} T \Uparrow}$ ✓ [6]

b.) $\mu = AI$ ✓

$A = \pi (r^2)$

$= \pi (4.1 \times 10^{-3} m)^2$

$I = 0.15A$

$\boxed{\mu_{loop} = 7.922 \times 10^{-6} A m^2}$ ✓ Direction? -1

✓ × -2

$\boxed{B_{loop} = 3.948 \times 10^{-3} T \Uparrow}$ -1

c.) $B_{loop} = \frac{\mu_0}{2} \frac{I R^2}{(z^2 + R^2)^{3/2}}$

$z = 3.5 \times 10^{-2} m$ $\quad I = 0.15A$

$R = 4.1 \times 10^{-3} m$

$\tau = 6.79 \times 10^{-11} Nm$ ✓

Part D on Back.

d.) $B_{wire} = \frac{\mu_0 I}{2\pi d}$ $I = 1.5A$

$d = 3.5 \times 10^{2} m$

$B_w = 8.571 \times 10^{-6} T$

$\tau = \mu B \sin\theta$ $\theta = 90°$

$\mu = 7.922 \times 10^{-6} Am^2$

$\tau = 6.79 \times 10^{-11} Nm$

2. Consider two very long, parallel wires with currents in opposite directions, as shown in the figure below.

   a) What is the magnetic field (direction and magnitude) of wire 1 at point a.

   b) What is the magnetic field (direction and magnitude) of wire 2 at point a.

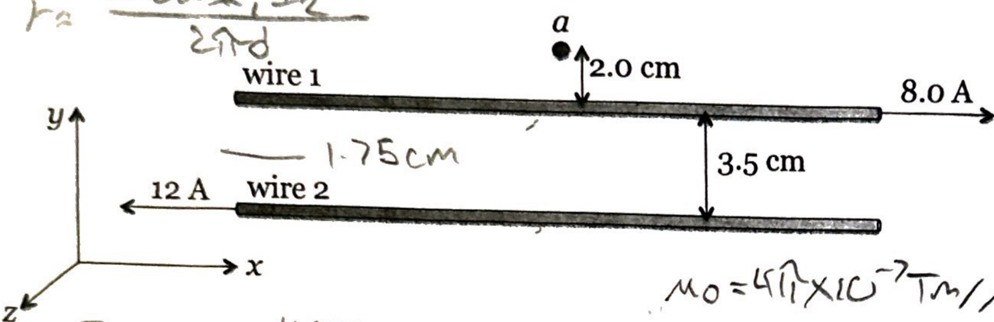
   c) What is the net magnetic field (direction and magnitude) of the two wires at point a?

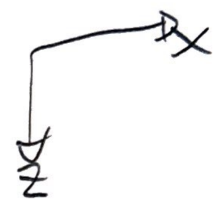
   Now consider an election moving with a velocity given by $\vec{v} = (1.2 \times 10^6 \text{ m/s})\,\hat{\imath}$.

   d) What is the magnetic force (direction and magnitude) on the electron due to the two wires when the electron passes over point a.

+14 / 20

$F = \frac{\mu_0 l I_1 I_2}{2\pi d}$





$\mu_0 = 4\pi \times 10^{-7}\ Tm/A$

$B_{wire} = \frac{\mu_0 I}{2\pi d}$

a.) 1.) $I = 8.0A$
$d = 2.0\times10^{-2}m$

$B_1 = \frac{\mu_0 (8.0A)}{2\pi(2.0\times10^{-2}m)}$ ✓ -1 $\boxed{B_1 = 8.0\times10^{-5}\,\hat{\jmath}\,T}$

b.) 2.) $I = 12A$
$d = 5.5\times10^{-2}m$

$B_2 = \frac{\mu_0 (12A)}{2\pi(5.5\times10^{-2}m)}$ ✓ -1 $\boxed{B_2 = 4.36\times10^{-5}\,(-\hat{\jmath})\,T}$

3.) $B_{net} = B_1 + B_2 = 1.24\times10^{-4}\,\hat{\jmath}$ ✓ ✗ -1 -1 $\boxed{B_{net} = 1.24\times10^{-4}\,T\,\hat{\jmath}}$

$F = I l B \sin\theta$

4.) $F = qvB\sin\theta$ ✓ $q = -1.602\times10^{-19}C$

$\theta = 90°$

$\frac{3.5}{2} =$

$F = F_1 + F_2$

$\boxed{F = 2.38\times10^{-17}N}$ ✗ -1

$F = -1.538\times10^{-17}N - 8.382\times10^{-18}N$ -1

3. A square loop with sides of length $\ell = 0.15$ m lies in the xy plane. The resistance of the square loop is $0.55\ \Omega$. The magnetic field in this region of space is a function of time and is of the form

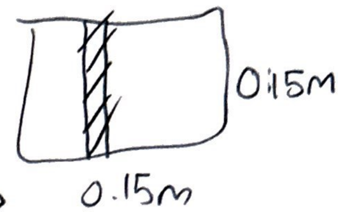
+12/20

$$\vec{B} = (0.32\,t)\hat{\imath} + (0.54\,t^2)\hat{k}, \tag{1}$$

where B is in tesla and t is in seconds.

a) Calculate the magnetic flux through the square loop at time t.

b) Calculate the induced current in the loop at $t = 0.50$ s.



$\emptyset = \int B \cdot dA$ +3 $\quad B = \langle \cancel{0.32t}, 0, 0.54t^2 \rangle$

$R = 0.55\,\Omega$

$A = (0.15m)^2$

$\frac{dB}{dt} = \langle 0.32, 0, 1.08t \rangle$ $\qquad \frac{I}{R} = \left|\frac{d\emptyset}{dt}\right|$

a.)

$\frac{dB}{dt} = 0.32\hat{\imath} + 1.08t\hat{k}$ $\qquad \emptyset = \int B \cdot dA$

+2

$$\boxed{\frac{dB}{dt} = 0.32\hat{\imath} + 0.54\hat{k}}$$

b.)

$\frac{I}{R} = \left|\frac{d\emptyset}{dt}\right|$ +3

$\theta = 0^\circ$ $\qquad \langle 0.32, 0, 0.54 \rangle$

$\frac{d\emptyset}{dt} = \frac{dB}{dt} A\cos\theta$ $\qquad B = 0.628\ T/s$

$\Delta V = IR$

$I = \frac{\Delta V}{R}$ $\qquad d\emptyset = dB\,A$ $\qquad A = 0.0225\ m^2$

+2

$I = \frac{\mathcal{E}}{R}$ +2 $\quad d\emptyset = (0.628\,T/s)(0.0225m)^2 = 0.014123\ Wb/s$

$\mathcal{E} = 0.028246V$

$I = \frac{0.028246V}{0.55\,\Omega}$ $\qquad I = 0.05A$ $\qquad \frac{d\emptyset}{dt} = \mathcal{E}$

4. Unpolarized light with intensity 350 W/m^2 passes first through a polarizing filter with its axis vertical, then through a second polarizing filter. It emerges from the second filter with an intensity of 131 W/m^2.

+8 / 20

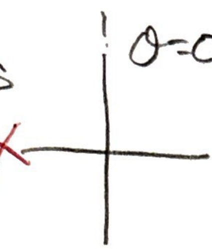
a) What is the intensity of the light after it passes through the first polarizing filter, but before it passes through the second?

b) What is the angle from vertical of the axis of the second polarizing filter?

a.) $I = I_0 \cos\theta^2$

vertical Axis

$\boxed{I = 350 W/m^2}$ ✗



$I_0 \cos\theta^2 = \frac{1}{2}$

$I_0 = 350\ W/m^2$

$\theta = 0$

$I = 350\ W/m^2 ((\cos(0))^2$

$I = 350\ W/m^2$

b.)

$I = I_0 \cos\theta^2$ +4

$I = 131\ W/m^2$ ✓ +4

$I_0 = 350 W/m^2$

$\sqrt{\frac{I}{I_0}} = \cos\theta$

$\cos^{-1}\left(\sqrt{\frac{I}{I_0}}\right) = \theta$

$\theta = 52.28^\circ$ from the vertical axis ✗

$I = \frac{P_s}{4\pi r^2}$